GEOLOGICAL SURVEY —— REPUBLIC OF BOTSWANA

REPORT

TITLE: TO ASSESS THE VALUE OF SATELLITE PHOTOGRAPHS IN RESOURCE EVALUATION ON A NATIONAL SCALE

ERTS-1 Type I - 1 REPORT

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CONTENTS: 17 PAGES: Discussion of significant results appears as abstract on title page

SR No. 9643

"To Assess the Value of Satellite Photographs in Resource Evaluation on a National Scale"

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"To Assess the Value of Satellite Photographs in Resource Evaluation on a National Scale"

17th. January 1973
September 1972 - December 1972.

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SMA/5/73 (report no.)
G.J. Ensor (technical monitor)

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Supplementary Notes: (1) This report was compiled by S.M. Akehurst, Project Manager, Botswana ERTS programme.
(2) The opinions voiced in this report are not necessarily those of the compiler or the Principal Investigator.
(3) The old system of stratigraphic nomenclature has been used in this report, as final decisions regarding geological nomenclature in Southern Africa have yet to be made.

Abstract: The first ERTS-1 data to be received in Botswana are assessed for their contribution to the present geological knowledge of the country and for hydrological and ecological information in restricted areas.

BOTSWANA GEOLOGICAL SURVEY AND MINES DEPARTMENT.

1st. ERTS-1 Type 1 Report

1. Title: To assess the value of satellite photographs in Resource Evaluation on a National scale.

2. SR - 9643 INT-BOT- 01

3. Major problems impeding the investigation.

All participants are agreed that the major obstacle to progress is the delay in receipt of imagery. The first photographs of Botswana were only received at the Geological Survey and Mines Department four days after the first report was due. The hydrological investigator, B.H. Wilson, noted that "only one set of imagery of the Okavango was received and this twelve weeks after taking". At the time of reporting " it was too late to make additional checks on ground truth related to such imagery"

W. von Richter who is studying vegetation changes and differences, remarked that "the major handicaps encountered in the evaluation and processing of the ERTS-1 data are the lack of suitably documented parameters in conventional methods which could serve as comparison and the preoccupation of the investigator with other more urgent departnental matters"

Similar arguments apply to workers at Geological Survey where the impossibility of establishing geological ground truth over the sand-burdened Kalahari tends to make the deductions that may be drawn from the ERTS imagery rather tentative. Regional geophysical surveys are in progress, but it will be some time before the whole country is adequately covered by these means.

4. Accomplishments.

The first data received of Botswana were taken during the third cycle of ERTS' world coverage.

As the imagery arrived, it was sorted and indexed by S.M Akehurst. Each image is classified primarily by co-ordinates of longitude and latitude, on the assumption that ERTS-1 is to record data on identical orbits every eighteen days. However, differences in registration of scenes from comparable orbits on successive cycles have become particularly marked after the fifth cycle.

A scheme for geological interpretation was devised by

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S.M. Akehurst and authorised by J.V. Hepworth. Copies are attached. During the next three months it is hoped that a geologist without previous experience of compiling the 1:1million national geological map will use the photographs in order to make a comparison with the results of interpretation from print laydowns and ground truth.

Due to the limited time period for compiling a report and the prior commitments of investigators in the field, the only other participants to report on this occasion are B.H. Wilson of the Department of Water Affairs and W. von Richter of the Department of Wildlife and National Parks. These two investigators will respectively continue to monitor water flow in the Okavango Delta and vegetation changes in the Chobe National Park.

5. Significant Results.

5.1. General All participants are agreed that band 7 (MSS7) gives by far the best resolution and contrast of the four MSS bands. There has been no RBV imagery for comparison.

Positive transparencies also seem to give better resolution than black and white prints. Therefore the 1:1million positive transparencies were used whenever possible in preference to the prints. Better contrast and more detail is seen on imagery taken just after heavy rainfall.

5.2. Geological Investigation The work was divided among eight investigators at BGSMD, named as follows: S.M. Akehurst, D. Gould, R.M. Key, M. Litherland, N.W.D. Massey, C.V. Reeves, G. Stansfield and I.R. Walker. Imagery of M. Litherland's area has not been taken at this date.

The consensus of opinion, save for two possible exceptions, is that the ERTS imagery does NOT show anymore detail than ordinary print laydowns or conventional aerial photography at a scale of 1:40 000, even when using MSS 7 imagery. D. Gould suggests that conventional photography reduced to 1:1 million would probably show more geological information and he and N. Massey believe that interpretation of an unknown area would be extremely difficult.

Major geological features and lineaments can be recognised, but as a whole the imagery is too indistinct for detailed mapping. Even

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low-power magnification causes obscuration by scan lines.

G. Stansfield welcomed the advantage of con stant monitoring of the country but believes this is hardly necessary for geological interpretation and that high altitude conventional photography would probably provide better imagery at a lower cost. He states "ERTS imagery lacks the definition, resolution and contrast of conventional aerial photographs."

On the other hand, R. Key does not believe that a comparison with ordinary aerial photographs is justified or necessary in view of the large differences in scale and to this end cites image 1050-07344-7 01 in which "the central zone of the Limpopo Mobile Belt can be traced right across the area, and the edge of the Karroo system can be defined" I. Walker agrees in this respect by pointing out that one ERTS scene comprises an area comparable to coverage by nine print laydowns at ': 1:125 000. "This means that large areas can be viewed and that large scale structures, changes in structure and relations between structures can be much more easily appreciated"

I. Walker and S. Akehurst have both noticed that areas which give maximum reflectance from white, light tone areas, e.g. pans and lines of fossil drainage, show particularly well on MSS 4 and MSS 5 as strongly contrasting to the surrounding dark tone areas.

Most of the workers agree that there is a tendency to look for features which are known to exist. Interpretation is highly subjective and could mean that unknown features will be missed. G. Stansfield also points out the "operator error" by which any one investigator may "see more" than his colleagues whether by being more observant or having a better imagination.

The Geologists who worked on the 1:1million National Geological map believe that the imagery would have been of use in the map's compilation.

Individual results follow:

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5.2.1 South-east Botswana. 1050-07350 The Limpopo River, dry at the time of sensing, crosses the scene from SW to NE dividing South Africa on the east from Botswana.

Ironically, structural trends in darker tone areas which probably represent schist belt fragments are easily detectable on the S. African side but are not apparent in Botswana where they have been mapped.

Two fairly large outcrops of Waterburg rocks stand out with ESE strike. Their faulted boundaries are not obvious in the photograph, but some sort of jointing or cross fracutre can be seen.

1069-07402 Within the area covered by this image, granitoid Basement rocks are overlain by Karroo to the west. Darker toned belt remnants and structural trends in the Basement can be distinguished in the north, but otherwise it seems practically impossible to trace lithological boundaries on the photograph.

There are traces of dyke swarms in the south-west, and two lineaments trending ENE to the north-west of Serule may well be the prolongations of major faults in the Mmadinare area to the east.

1069-07411 With some assistance from the 1:125 000 geological map, it is possible to draw in geologic al boundaries in the south between Gaborone, Lobatse and Kanye, where the Kanye felsite and Waterburg Group together form a prominent topographic feature. An "inlier" of Kanye felsite north-east of Gaborone stands out remarkably, while an outcrop of dolerite just north of Mochudi would appear from the photograph to have a rather greater extent than was originally mapped. Small outcrops of syenite may be detected south of Molepolole.

The outcrop of the Transvaal System presents a rather contorted pattern which is nevertheless decipherable as an elongate syncline bounded by scarp slopes facing outward from the centre. Mapping of the limited outcrop in Botswana has revealed considerable faulting within the Transvaal System which might explain the confusion of structural detail on the image.

Waterburg rocks outcrop again to the north of Gaborone. The boundary may be distinguished on the image as an escarpment, the rocks

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themselves being darker in tone than the Gaborone granite bordering to the south.

Faulting is evident in the Kanye area and cross-fractures are prominent in the Waterburg rocks.

Very little can be deciphered in the north of the image where exposure is poor on the ground in any case. Lineaments trend NE-SW or NW-SE.

A scarp which marks the edge of the westward receding erosion surface between the sand-covered Kalahari to the west and the predominantly Precambrian rocks to the east is quite clear. It appears to be a watershed. A number of small dry valleys drain eastward from the scarp while drainage to the west flows north towards the Makgadikgadi.

1069-07414M Ventersdorp Volcanics NW of the Taupone Fault are distinguished by their light tone and higher relief from the surrounding rocks, but cannot be detected so easily to the SE of the fault.

Several lineaments in the Lobatse area trend ENE-WSW. Foliation traces and outcrop boundaries in the Transvaal System just west of the Segkwagkwa syenite may be tentatively deduced.

The most evident geological geatures are the outcrop of the Transvaal System which swings round in a series of scarps from N-S to NW-SE to W-E, and the Segkwagkwa, Mmathethe and Masoke-complex intrusions in the northwest. These intrusions are light in tone; the dolerite and syenite intruding Transvaal System shale are easily differentiated in the Masoke intrusion. (S.M.A.)

1050-07344-4 The larger sand rivers in the area are shown clearly- Shashe, Ramokgwabane, Tati and the Motloutse. However, where the Motloutse drains basalt areas, the material in the bed becomes darker in colour, making the course of the river harder to trace. The Thune river is only discernable in part. Minor drainage features in the western part of the photographs are clearly seen. The dark trace of the river Limpopo indicates the presence of water.

Faults marking the northern boundary of the Bobonong basalt area

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are traceable as a junction of two areas of different tones; the Letlhakane fault near Mmadinare is also noticeable. The banded ironstone which crosses the border between Botswana and Rhodesia at Matsiloje forms a prominent ridge which can be easily picked out on the image. The basic and ultrabasic rocks of the Tati Schistbelt tend to be slightly darker in tone than the surrounding areas but no boundary could be drawn on the image in this wavelength.

1050-07344-5 All the features noticed on MSS 4 can be traced on MSS 5 and considerably more detail is discernable. The Motloutse and Thune rivers are much clearer, and the main road and railway are distinctly visible in the western part of the image where Francistown shows up as a light-toned patch.

The boundary of the basic rocks, schists etc. of the Tati Schistbelt can be delineated in placds, and the strike of certain horizons, giving particularly dark tints, is clearly shown. The granitic inselbergs of the Lipdkolo Hills are prominent. Various E-W elements, probably representing Karroo dolerite dykes, are visible on the Rhodesian side but not in Botswana.

1050-07344-6 Very similar to MSS 5. Additional information includes the boundary of the Bobonong basalt area and more strike lines in the Tati and Selebi areas.

1050-07344-7 This is much the best band for distinguishing geological features.

The Karroo basalts around Bobonong give a much darker tone than the surrounding Karroo sediments and Pre-Cambrian acid gneisses. One or two escarpments due to the gentle northerly dip of the lavas can also be seen, but the patches of quartz-agate gravel weathered out on the dip slope cannot be distinguished.

The Tati Schist-belt can be easily distinghished, being darker than the surrounding acid gneiss though lighter in tone than the basalts. The central zone of the Limpopo Mobile Belt and possible "outliers" of it can be traced ritht across the centre of the image. The ironstone ridge at Matsiloje is particularly conspicuous.

In the mann gneissose area, strike traces can be followed in a number of places, particularly near Baines' Drift. A feature which may be

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the Selebi basin was noticed, but it was very indistinct. Post-Karroo dykes can be traced in a few places, but their alignment (ESE) is almost parallel to the grain of the imagery which causes confusion. (D.G. and R.M.K.)

1049-07290-4 The Botswana part of this image shows very little geological detail such as the northern faulted boundary of the Karroo basalt area and some possible strike trends in the gneissose rocks to the north of the fault. The dry rivers, (Thune, Motloutse, Limpopo and Shashe) are conspicuous.

1049-07290-5 In addition to the features discernable in MSS 4, the trace of the river Mojale may be detected as a dark line, due to the large trees along the banks. The basalt area is distinguished from the gneissose rocks by a darker tone, the Karroo sediments being generally lighter in tone than the gneiss. A dyke cutting Karroo sediments produced a prominent feature.

1049-07290-6 As MSS 5, except that the basalt-sedi-/ment boundary is less distinct and the Karroo sediment-gneiss boundary is more distinct.

1049-07290-7 Little detail additional to MSS 5 and 6 is visible. Small rivers less easy to discern due to dark tone of basalt area.

1103-07294-4,5,6,7 This imagery covers virtually the same area as 1049-07290 and is closely comparable to it except that contrast is slightly better for each wavelength giving some additional detail. A comparison of MSS 7 with the earlier imagery shows that the Motloutse river is more conspicuous, several more basalt scarps can be discerned and strike lines in the Baines Drift area are more obvious. (D.G.)

1050-7350M and 1069-7405M Mahalapye - Palapye - Martins' Drift On both sets of imagery, the road and rail systems are clearly seen. Settlements within the area covered by this imagery include Palapye, Mahalapye, Dibete, Serowe and Shushong.

1050-7350M Rock outcrop east of Palapye is possibly Waterberg System. Thinly sand-covered areas reveal bedrock geology to the north-east (Baines Drift), where deformation in the Basement Complex is easily seen (foliation/bedding and marker horizons), and to the south-west (Machaneng). The Zoetfontein fault is only visible in the south-west. Jointing is very dominant in an outcrop area in the south-east of the image (Transvaal.).

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1069-07405M Kalahari Sands are well developed to the north-west of the image. Sand dunes may be seen trending NE-SW. The edge of the Sandveldt is moderately defined; outcrops may be detected around Serowe, Shushong and Palapye. Structural features visible are mainly joints with some bedding/foliation. The Zoetfontein fault may be seen in the south-west, possibly dykes in the central southern portion of the image. A general impression of NW-SE fabric can be discerned in the Basement Complex area to the east of Mahalapye and in the west of the image. There is a strong contrast between the Shushong volcanics and sediments. (N.W.D.M.)

5.2.2. North-east Botswana 1052-07452M This image covers the north-eastern border of Botswana with Rhodesia. Victoria Falls is situated in the extreme north-east.

Apart from the extensive burnt patches on both sides of the border and the widely spaced dunes trending ENE-WSW covering the southern half of the scene, there is some rock outcrop in the north-east. Scarps receding north-east must indicate Karroo rocks which surround Wankie (Rhodesia). Strongly defined lineaments trending NE-SW in this area are clearly visible. Shorter lineaments some 70 km west of Wankie trend NW-SE.

Rivers on the national 1: 1million map do not register with those on the imagery. (S.M.A.)

5.2.3. Makgadikgadi Area 1052-07454M The structural control of the area is clearly defined. Several of the faults appear to control the salt pan margins in this region trending NE-SW, the direction which parallels the line of best fit for a series of earthquake epicentres in the Central Kalahari (Reeves 1972). A series of secondary faults trend NW-SE.

The most north-easterly part of Sua Pan was still moist; the dry river beds of the Nata, Simanwane, Shuane, Lepashe and Motsitamma rivers were especially visible on MSS 5. Barchan dunes border Sua and Ntwetwe Pans, the lee slopes facing west. A field of large linear dunes north of Nata trend approximately E-W.

A NW-SE fabric characterises the outcrop of Basement Complex south of the Shuane River.

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1052-07461M The area covered by this image occurs to the south of the previous one. Extensions of the NE-SW fault system apparently controlling the outline of the Makgadikgadi pans are visible. Water in the Boteti river leading into Mopipi reservoir for the Orapa mine is also clearly shown. E-W linear dunes and barchan dunes can be detected and the Mosu Scarp can be traced. The Francistown-Orapa road and large burnt areas are other distinctive features. The shallow Letlhakane "valley" and the road from Mopipi to Orapa are less clear. (G.S.)

5.2.4. Central and Southern Kalahari. 1052-07463M The most notable features of this scene which lies in the eastern-central Kalahari and the northern Kweneng district, are the widespread NE-SW trending faint furrow lines (Grove 1969) reflected by vegetation differences. However, there seems to be an interference pattern, not recorded by Grove, in the area covered by quarter degree square 2224 D. The most probable interpretation of this pattern is that the furrow lines represent ancient linear dunes which have been degraded by weathering processes, so that they have broken up and shifted to form chevron type figures also easily distinguishable on the print laydown.

On the other hand, there is a possibility that some of the furrow ridges represent sub-surface structural trends, which are either underlying dykes or correlatable with a similar phenomenon at Orapa (Sellschop et al 1972) where linear vegetation trends may reflect jointing in the underlying Karroo basalt. "The lines show parallel orientation. Occasionally, two such sets of lines intersect" (ibid. p.11). This may indicate a reasonable groundwater potential. The area is remote, there are no boreholes in the vicinity, no settlements and the Geological Survey has as yet been unable to geophysically survey the terrain, although a national gravity survey is in progress with the intention of elucidating sub-Kalahari sand features.

There are some uncertain lineaments trending NNW-SSE in the Kweneng District; otherwise, the distinctive features of this image are the black burnt-out areas and white patches which reflect former fires and overgrazing.

1052-07470M This image covers parts of the Kweneng District, the Ngwaketse District, the Molopo and the Barolong Farms. Geologically, there is little to see except that the Sekgwakgwa syenite complex is clearly defined by tonal contrast and some foliation is visible in the Transvaal System some 40 km south-west and 80 km west of Kanye where faulting is also faintly detectable.

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At the extreme edge of the image, outliers of Waterburg System are readily distinguished by their topographic expression and tonal contrast from the Gaborone Granite. The sharp boundary between the granite and a darker toned area to the west is the escarpment bordering the Kalahari. There are possibly a few lineaments in this sand blanketed area with an average trend of NW-SE. Faulting of Ventersdorp Volcanics near Kanye is well defined.

1052-07472M Apart from two faint and uncertain lineaments trending WSW-ENE, no geology is visible north of the dry Molopo river which is the border between Botswana and South Africa. (S.M.A.)

1053-07513, 07515, 07522, 07524, 07531, 07533M These images cover a strip of country extending south-south-west from the west of Ntwetwe Pan to Werda and the northern Cape Province (S. frica). Little or no geological detail can be identified except within the northern Cape. Much of the detail is topographic such as dune fields, dry rivers, pans etc.

053-07513M This image is dominated by the Boteti river and the western edge of Ntwetwe Pan. The edge of the pan is very irregular and not very clear due to invasion by barchan dunes. The trend of an old strandline running N-S in the centre of the image is possibly due to structural control. Linear dunes trend generally E-W but there is an area of "rippling" in the north-west.

1053-07515M The predominant trend of a linear dune field is approximately E-W but in the north-west and north-east of the image there is a "rippled" set of N-S trending dunes imposed on them. An old strandline of the Makgadikgadi is clearly visible as are Lake Xau, the Mopipi reservoir and the eastern section of the Boteti river.

1053-07522M Linear dunes trend E-W but curve in the south-west corner of the image to a south -westerly direction. Pans are common in the southern half of the image e.g. Kang, Boritse and Dutlwe.

1053-07524M This image is dominated by pans e.g. Khakhea, Sekguma, which often show crescent dunes on the south or south-west sides. There is a large dyke feature in the Khakhea area and some lineaments in the Molopo Farms region north of the Molopo river..

1053-07531M The Molopo river crosses this image. Dunes in the south-west

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trend approximately NNW-SSE. Rock outcrops under thin sand cover at Tshabong reveal some faulting and bedding/foliation.

1053-07533M Most of this image lies in the northern Cape. A small area of Botswana, around Khuis, may also be seen. Dunes trend NNW-SSE. Considerable rock outcrop in the central and eastern part of the image shows faulting and bedding/foliation etc. (N.W.D.M.)

5.2.5. Okavango Swamp Area. 1053-07510M, 1054-07565, 07571, M 1055-08021, 08023. M Various topographic features are clearly discernable.

The major features are the Okavango Swampland and the Linyanti Swamps. To the west of this is a region of long linear dunes trending approximately WNW-ESE. The Mabebe Depression lies to the east and Ngamiland to the south. Several groups of hill stand out such as the Tsodilo Hills (1055-08023) the Goha, Shinamba and Guabatsa Hills (1053-07510) and the Kgwebe Hills and Mabèlè-a-Podi (1054-07571). Lake Ngami and its old strandlines are clearly visible on 1054-07571.

The major geological features are the faults controlling the damming of the swamps which trend NE-SW in the Maun area (1054-07565, 07571), the faults within the swamp area (1054-07565, 1055-08023) the fault damming the Linyanti swamps and forming the route of the Chobe river (1054-07565), and faults controlling the Okavango and Linyanti channels (1055-08021, 08023). The only bedrock visible is the Ghanzi Ridge in Ngamiland where various faults and bedding/foliation lineaments are discernable under relatively thin sand cover. (N.W.D.M.)

5.2.6. Western Kalahari Border 1056-08084M South-West Africa. Structural detail in the Aha Hills. E-W trending linear dunes. NE-SW faulting largely of post-dune, pre-drainage age. Fossil drainage pattern superimposed on and largely controlled by the dune and fault trends. Drainage flowing eastwards to Lake Ngami/Okavango area.

1056-08091M South-West Africa, Botswana, Okwa Valley. Structural detail of Ghanzi Formation and Tsumis Formation (South-West Africa), also lithology and cross-fracture. NE-SW faulting.

E-W linear dunes, remnant N-S linear dunes, pans. Superimposed

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fossil drainage pattern flowing east and north-east toward the Lake Ngami/ Okavango area. Farm boundary pattern in South-West Africa) related to grazing.

1056-08093M South-West Africa, Botswana. Structural detail of Tsumis Formation possibly equivalent to the Ghanzi Formation, and the Buschmanns-klippe Formation in South-West Africa. NW-SE linear dunes, Nossob river, pans, many of elongate inter-dune form. International boundary, roads, farm boundaries.

1073-08030M South-West Africa, Botswana. Structural detail in Aha Hills, NE-SW faulting. Fossil drainage pattern superimposed on and largely controlled by dune and fault trends. Western part of Okavango Swamps and a large area of 'washed out' dune field. International boundary, cloud cover.

1073-08032 M South-West Africa, Botswana, Hanahai, Okwa. Structural detail of Ghanzi Formation and Tsumis Formation (South-West Africa). NE-SW faulting. E-W linear dunes; Fossil drainage pattern: in the north-west, superimposed on dune and fault trends and flowing towards the Okavango, and in the south-east, the Hanahai and Okwa drain eastwards towards the central Kalahari Basin. The Ghanzi Ridge forms a drainage divide between these two systems. Pans, international boundary, cloud cover.

1073-08035 M South-West Africa, Botswana, Okwa. Linear dune pattern, fossil drainage: the Okwa valley drains eastwards. Pans, international boundary.

1073-08041 M South-West Africa, Botswana, N-S linear dunes. Fossil drainage: Nossob river. Pans, many of elongate inter-dune form. International boundary.

1073-08044M South-West Africa, Botswana. NW-SE linear dunes, pans. Fossil drainage: Nossob river. (I.R.W.)

1072-07583 M Almost half of this image is obscured by cloud cover, indicating rain moving away to the north-west. MSS 4 shows pans and outlines cloud cover better than band 7; tone is generally lighter on MSS 7 than MSS 4, but is darker than usual for the imagery due to the recent rain. Some pans immediately behind the weather front appear quite dark on MSS 7 which implies that they were still moist. In the south-west of the image there are a number

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of degraded linear dunes trending NNW-SSE. Pans, elongated N-S, are practically ubiquitous in this sand-covered area.

1072-07585M As in the previous image, pans and also dry river beds show well as light tone areas on MSS 4. MSS 7 shows linear dunes in fair detail. Old degraded dunes trend NNW-SSE while more recent, very closely-spaced dunes perpendicular to the old drainage, swing from a WNW-ESE trend at the west of the image to NNW-SSE at the east of the image. "Ribbon" patterns trending NE-SW are characteristic in which dunes of 4-8 km length trend perpendicularly to sinuous lines (fossil drainage?) of 30 - 40 km length. Elongate pans are common, but smaller than in the area to the north. The Nossob river, a dry river which used to drain south-westwards to the Atlantic Ocean, marks the common boundary between Botswana and South Africa.

1072-07592M The confluence of the dry Nossob and Molopo rivers shown on this image represents the southernmost point of Botswana at the boundary between Botswana and South Africa.

Bedrock emerges from the sand cover at the extreme east of the image. A field of very closely spaced linear dunes covers half of the area showing, as in the area to the north, a change in trend from NW-SE in the west to NNW-SSE in the east. There are several large pans scattered in the west, some about 5 km long, and elongate inter-dune pans are also apparent.

Three parallel lineaments trending NNW-SSE and of very indefinite nature may be detected on this image. One of these lineaments appears to divert the course of the Molopo and the dry valley to the south for a short way; the trend of the lineament, although roughly parallel to the dune direction in this locality, does cross it. Furthermore, no dunes may be seen between the two river courses at this point. (S.M.A.)

5.2.7. Conclusions of the Geological Investigation This description has been lengthy because it is an attempt to give a fairly accurate idea of exactly what geology can be seen from the satellite imagery. Future reports will only summarise new results obtained from study of the data.

As far as the original objectives are concerned, the imagery has confirmed the faulting in the Okavango Swamps and revealed further lineaments. There is a definite major NE-SW trend throughout Botswana which is very well shown on imagery of the Makgadikgadi paralleled by the trend of

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the Ghanzi Ridge further to the west. A secondary trend running NW-SE is also quite important.

The imagery would have been extremely valuable in compiling the National Geological Map if it had arrived in time. It will probably be used when the map is revised. After the bulk of the imagery had been reviewed, C.V. Reeves produced a 1:1 million gravity map of the Okavango Delta. The fault traces on the map co-incided exactly with the lineaments clearly visible on theimagery, thus entailing some revision already to the national map.

Large-scale trends in eastern Botswana have not been as clearly defined as could have been hoped, and are practically non-existent in the Kalahari.

Such small-scale imagery is usefully available for general reference and takes up little storage room. (S.M.A.)

5.3. Hydrological Investigation The imagery (1054-07565, 07571 and 1055-08023) was examined with two specific objectives in mind:

(a) whether flood fronts could be pinpointed for those rivers which advance seasonally along, initially dry, watercourses,

(b) whether a quantitative assessment of the general area of flooding at a given time could be made by routine, objective densitometric measurements, without much intelligent interpretation.

The date of the first imagery happened to correspond with the maximum extent of flooding at the Okavango Swamp downstream margins. And this, being five months after rainfall, should have given maximum contrast.

The immediate answer to (b) is, unfortunately, NO. The reason is that the aquatic vegetation, more particularly papyrus, provides a thick canopy covering much of the flooded area, which therefore comes out light and not dark on MSS band 7. The imagery, particularly in the IR bands, will, however, still prove of great value in determining the area of flooding and its variation in time but this will require detailed intelligent work with subjective judgements.

There is not yet a clear answer to question (a). Comparison has been made with ten small and critical areas of known, interpolated or extrapolated ground truth, some obtained by charter air flights. Imagery in MSS

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band 7 indicated water ronts quite accurately in some areas, but in other areas the results are quite misleading. Resolution is the main factor but not the only one. One case greatly underestimated the flood front of a river. Another case suggested some water in Lake Ngami which had been dry for many weeks. Examination of subsequent imagery may, hopefully, reveal the cause of these discrepancies. In one or two cases, MSS band 5 revealed a watercourse better than band 7. This is probably due to vegetation, but as this may be a residual from a previous flood, it is not a good indication of flooding at a particular date. Bush fires confuse the imagery somewhat, but commonsense can often be applied.

Other useful information has been obtained from the imagery concerning the nature of the tributary rivers to the Okavango outside Botswana, e.g. whether they are swampy or have dry banks. (B.H. Wilson)

5.4. Ecological Investigation Preliminary examination of several sets of imageries revealed the usefulness for the mapping of district vegetation types in various National Parks and Game Reserves in Botswana. However, the examination also showed that existing vegetation maps of several Game Reserves are insufficient in detail for use as ground truth objects for vegetation mapping of other unmapped conservation areas. It will be necessary, therefore, to carry out more detailed field work in selected areas in order to be able to make optimum use of the satellite photography.

Of great practical importance is the regular coverage of the study areas by subsequent photography throughout the various seasons. On two subsequent imageries the extent and localities of wild fires could be traced. The changing vegetation, due to rainfall in the period between photography, could clearly be picked out and the extent of ephemeral streams and pans (natural depressions which hold water during and shortly after the rainy season) showed up also.

With more imageries becoming available covering a greater period of time it should be possible to follow more closely and in greater detail seasonal changes in the vegetation of selected areas. It is proposed to compile maps for selected areas on a seasonal basis and evaluate the recorded changes in the imagery using ground observations and existing vegetation maps.

(W. von Richter)

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6. Publications

One article was published prior to receipt of the imagery: "Botswana's participation in the Earth Resources Observation Project" AKEHURST, S.M., 'Kutlwano', November 1972.

7. Recommendations

At the moment, it is uncertain whether or not Botswana will receive regular repeat coverage, essential to the hydrological, ecological and agricultural programmes which are concerned with the continual monitoring of resources.

Much of the imagery so far received has been taken during the dry season. If the present drought breaks, it would be interesting to see if geological detail is any clearer after the rains.

It would certainly be advantageous to receive the imagery more speedily than at present. The value of investigative effort of the Okavango is reduced in proportion to the length of delay in obtaining the imagery. However, von Richter points out that "even if at present the data cannot be utilized to the optimum, they should be of great value in the future when more time and resources can be allocated to the evaluation"

The standing order for imagery was reduced to MSS bands 5 and 7 at the end of December 1972. Application will be made to NASA for the provision of system-corrected colour data for selected areas of Botswana.

8. Image Descriptor Forms

Image Descriptor forms were despatched to NASA on the 8th. January, 1973.

References: GROVE, A.T., "Landforms and climatic change in the Kalahari and Ngamiland" Geographical Journal, 135 (2), June 1969.

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SELLSCHOP, J.P.F., VERHAGEN, B.Th., MAZOR, E., "Groundwaters at Orapa, Botswana - Isotopic, Chemical and Hydrological Studies" Report of the Nuclear Physics Research Unit, University of the Witwatersrand, Johannesburg 1972.